Lake Boren Water Quality

A Report on Water Quality Monitoring Results
for Water Year 2011

Lake Boren *Photo by KC Lake Stewardship Program*

Prepared for the City of Newcastle
by the King County Lake Stewardship Program

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King County

OVERVIEW

The King County Lake Stewardship Program (KCLSP) began working with volunteer monitors to monitor Lake Boren in 1994 and have continued to the present with gaps in 1995 through1996, and in 2006. In 2005, the City of Newcastle began contracting with KCLSP to fund the monitoring effort in Lake Boren, including monitoring of fecal coliform bacteria. The longer term water quality data indicate that currently the lake has moderate algae productivity (mesotrophic) with fairly good water quality.

Although there is no longer a trailer-accessible public access boat launch, there is a large park on the southwest shoreline of the lake where members of the public can launch small car-top boats and get into the water, as well as fish from a large dock. The Washington Department of Fish and Wildlife continues to stock the lake each year with approximately 1,000 8-12" rainbow trout every year, but in 2011 no fry were included.

Residents and lake users should keep a watch on aquatic plants growing near the shore to catch early infestations of Brazilian elodea or other noxious weeds. The lake is known to host a non-native tape grass (*Vallisneria americana*), which does not appear to be causing any major problems. Eurasian watermilfoil, which is legally defined as a noxious weed within the state of Washitgnon, has also been identified in the lake, and this should be monitored for spreading.

This report refers to two common measures used to predict water quality in lakes. The Trophic State Index or TSI (Carlson 1977) is a method of calculating indicators from collected data that allows comparison between different parameters and predicts the volume of algae present in the lake.

A second measure is the nitrogen-to-phosphorus ratio (N:P), which is used to predict what groups of algae may become dominant in the lake during certain periods. Ratios in the low 20s and below indicate that nutrient conditions may be favorable to bluegreen algae that can use atmospheric nitrogen in addition to nitrogen in the water. Some of these algae are known to make chemicals toxic to mammals.

Both the TSI and N:P ratios have been calculated using the available data collected through the volunteer monitoring program.

The discussion in this report focuses on the 2011 water year. Specific water quality data used to generate the charts in this report can be downloaded from the King County Lake Stewardship data website at:

http://your.kingcounty.gov/dnrp/wlr/water-resources/small-lakes/data/default.aspx

Or can be provided in the form of excel files upon request.

Physical Parameters

No Level I volunteer was available to monito the lake this year, so no daily lake levels or precipitation measurements were taken. Both Secchi transparency and water temperatures

were measured during the water sampling events, which began in May and lasted through October.

Secchi transparency is a common method used to assess and compare water clarity. It is a measure of the water depth at which a black-and-white disk disappears from view when lowered from the water surface.

For Lake Boren, Secchi transparency was measured during May through October and values ranged from 2.5 m to 5.0 m, averaging 4.0 m (Figure 2). This puts Lake Boren in the mid-range of clarity for the 12 King County small lakes monitored in 2011. It appears as if water clarity remained relatively stable throughout the spring and early summer and then decreased in fall, with the highest clarity in mid July and the lowest clarity occurring in late October, due to late season algae blooms (note that the Y-axis is traditionally reversed on Secchi charts to mimic looking into the water).

Similar to data collected in previous years, the Secchi transparency values exhibited normal variability through the season.

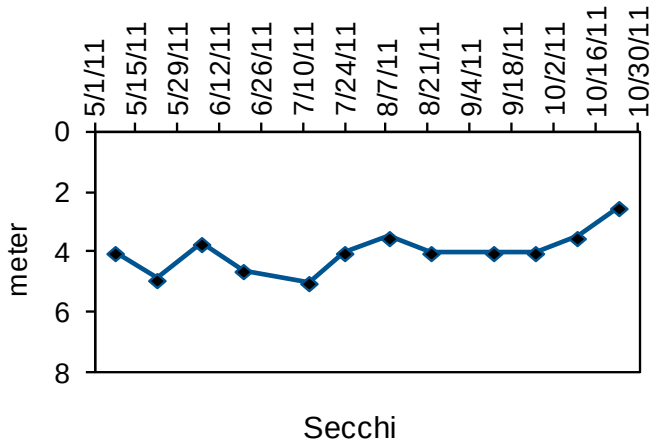

Figure 2. Lake Boren Secchi Transparency

Water temperatures during the May–October sampling period generally followed a pattern similar to other lakes in the region; the cool, cloudy weather recorded in Spring 2011 reflected in cool water temperatures, followed by summer maximum temperatures occurring in early August, and progressive cooling in the fall (Figure 3). The water temperature at Lake Boren ranged from 13.0 to 22.0 degrees Celsius with an average seasonal temperature of 18.0 degrees Celsius, which is very similar to 2010 when it was 17.7 degrees. Compared to other lakes monitored through the program, Lake Boren placed in the mid range of summer temperature maxima for the epilimnion (upper layer of shallow water).

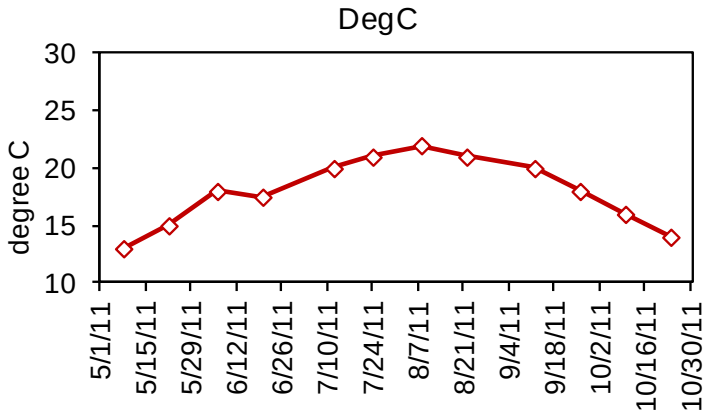

Figure 3. Lake Boren Water Temperatures

Nutrient and Chlorophyll Analysis

Phosphorus and nitrogen are naturally occurring elements that are necessary in small amounts for both plants and animals for healthy growth and reproduction. However, many actions associated with urban development can increase concentrations of these nutrients beyond natural levels.

In lakes of the Puget Sound lowlands, phosphorus is often the nutrient in least supply, meaning that biological productivity is often limited by the amount of available phosphorus. Increases in phosphorus concentrations can lead to more frequent and dense algae blooms, which are a nuisance to residents and lake users. They can also become a potential safety threat if blooms become dominated by certain cyanobacterial species (also known as "bluegreen algae") that can produce toxins. The ratio of nitrogen to phosphorus (N:P, see discussion in overview) can be used to determine if nutrient conditions were favorable for cyanobacterial growth. Of course, physical conditions and species competitions are also important factors.

Samples collected by volunteers are analyzed for total phosphorus (TP) and total nitrogen (TN) concentrations at one meter depth between May and October, with deeper water analyzed twice through the season, May and August respectively.

TN decreased throughout the spring and early summer reaching its lowest point at the end of July and then increased slightly throughout the rest of the sampling season. TP was steady through the spring and early summer and then increased in tandem with TN (Figure 4).

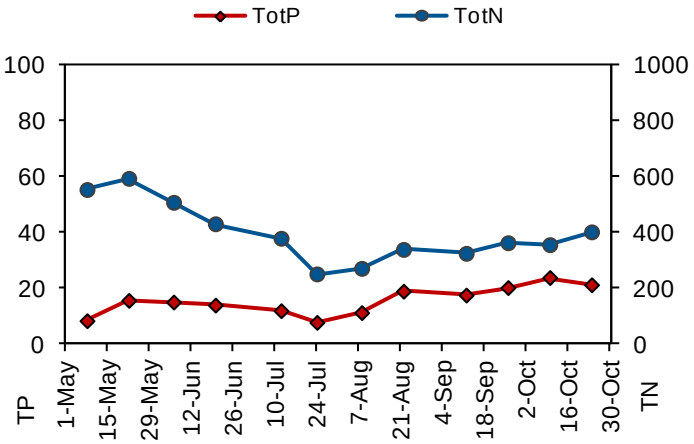

Figure 4. Lake Boren Nutrients

N : P ratios

The ratio of nitrogen to phosphorus (N:P) can be used to determine if nutrient conditions are favorable for the growth of cyanobacteria (bluegreen algae) that can impact beneficial uses of the lake. When N:P ratios are near or below 20, cyanobacteria often dominate the algal community due to their ability to take nitrogen from the air.

In 2011, the N:P ratio varied from 15 to 67.4 with an average of 29.1, which suggests nutrient conditions in the lake were near the threshold for favoring cyanobacteria. N:P ratios were somewhat unfavorable for bluegreens in the spring and early summer, but by August ratios were consistently below 20, which indicated good nutrient conditions for a late season bloom of cyanobacteria.

Chlorophyll

Chlorophyll a

Chlorophyll concentrations relate to the amount of algae present in lake water. All algae must have chlorophyll in order to fix energy from sunlight, so higher amounts of chlorophyll denote more abundant algae. However, some of the cyanobacteria (bluegreen algae) also use other pigments to capture light, so their relative amounts of chlorophyll per cell volume may be smaller than for other groups of algae. Pheophytin is a degradation product of chlorophyll, and large amounts present in a sample can indicate the presence of sediment detritus or other sources of old chlorophyll, in addition to that contained in vibrant, living algae. Some of these additions can be caused by wind and rain storms, sediment disturbance, bank erosion, or wash-in from watershed activities.

The 2011 values were fairly low throughout the spring and early summer at Lake Boren (Figure 5). However, values increased dramatically in late September through October, concurrently with the nutrient increases, indicating that algae were able to reproduce and maintain large populations in the fall when the N:P ratio was low. Pheophytin remained relatively low and static throughout the majority of the season.

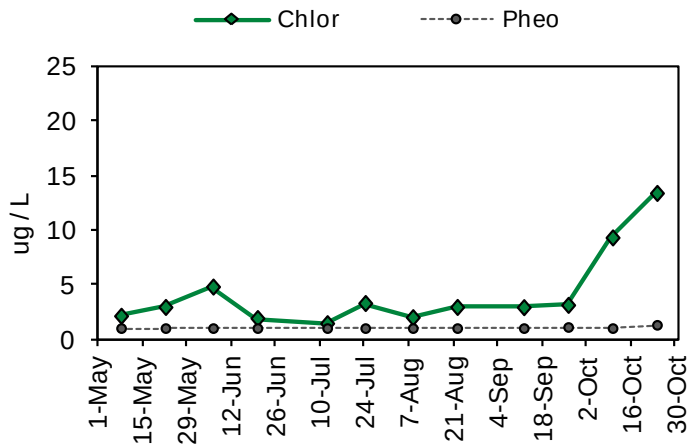

Figure 5. Lake Boren Chlorophyll *a* and Pheophytin Concentrations

The difference between shallow and deep water temperatures during the first profile event suggested the lake was thermally stratified, and it remained so in late August (Table 1). Total nitrogen and phosphorus were slightly elevated in the deep water during both profile events. The OPO4 (orthophosphate) values are high enough in the deep water relative to the shallow water values during both events to suggest that phosphorus release from the sediments to the water was significant in the summer. Oxygen depletion in the deep water that contributes to release of phosphorus from bottom sediments is confirmed by the presence of increased amounts of ammonia (NH3) which is present in low oxygen environments. In addition, there was an increase in Chlorophyll *a* and nutrients in the August mid-depth sample, which suggests that enough light was reaching the deeper water to stimulate growth of an algae population in the upper hypolimnion at or below the thermocline. This is similar to the pattern seen in 2010.

Table 1. Lake Boren Profile Sample Analysis Results. Secchi and Depth in meters. Temperature in degrees Celsius. Chlorophyll and Pheophytin in ug/L. Nitrogen, phosphorus, and alkalinity in mg /L. UV254 is in absorption units. Sample values below minimum detection level are marked <MDL.

Lake name	Date	Secchi	Depth	DegC	Chlor-a	Pheo	Total N	NH3	Total P	OPO4	UV254	Total Alk
Boren	5/22/11	4.9	1	15.0	2.9	<MDL	0.593	0.027	0.0155	<MDL	0.151	54.1
Boren	5/22/11		5	11.0	3.2	<MDL	0.627		0.0121			
Boren	5/22/11		9	7.0	0.9	1.2	0.925	0.050	0.0418	0.0039		
Boren	8/22/11	4.0	1	21.0	2.9	<MDL	0.338	0.008	0.0188	<MDL	0.120	65.0
Boren	8/22/11		5	17.0	14.7	4.3	0.918		0.0377			
Boren	8/22/11		9	8.0	6.9		0.680	0.356	0.0462	0.0153		

The values of the UV254 indicate that the water is relatively clear, with a little coloration from organic substances. The total alkalinity (Total Alk) measurement indicates that the water in the lake contains more buffering agents (usually expressed as dissolved calcium carbonate in mg/L) than other small lakes in the area and thus is better protected from pH change than many regional lakes.

The Trophic State Index

A common method of tracking water quality trends in lakes is by calculating the "trophic state index" (TSI), developed by Robert Carlson in 1977. TSI indicators predict the

biological productivity of the lake based on water clarity (Secchi) and measured concentrations of Total P and chlorophyll *a*.

In Lake Boren, all of the 2011 TSI indicators were close together, placing the lake in the low mesotrophic range, similar to the past three years (Figure 6). The indicators suggest that the lake has been relatively stable in terms of nutrient concentrations, with some year to year variability. When a trend line is added to the annual TSI values, it suggests there may be a slight trend upward in TSI values since 1998; however the correlation coefficient for the regression is low, suggesting that the trend line is poorly substantiated.

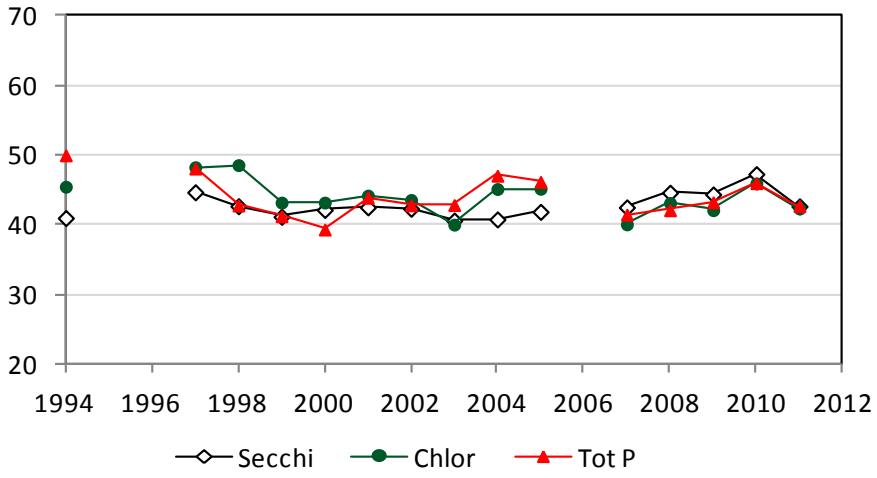

Figure 6. TSI Values at Lake Boren

Conclusions and Recommendations

Based on monitoring data, water quality as measured by nutrients and chlorophyll in Lake Boren has been stable over the last decade of monitoring. In 2011, nutrient concentrations were fairly static until phosphorus increased relative to nitrogen, resulting in lower N:P ratios at the end of the season. This indicates that conditions may have favored nuisance bluegreen algae blooms in late summer through fall.

There may be a slight trend towards nutrient increases and transparency decrease over time as suggested by the TSI indicators, but currently the statistical validation is weak. Continued monitoring of nutrient and chlorophyll *a* concentrations to assess conditions annually would be beneficial to make sure that stability is being maintained long term.

Future algae blooms should be reported for evaluation by the Washington State Department of Ecology's Toxic Algae Monitoring Program to determine whether or not blooms at the lake may be producing toxins.

The City of Newcastle also has contracted with KCLSP to perform fecal coliform analysis in addition to bimonthly growth season monitoring. A separate summary report has been written discussing the results and conclusions of that effort.